



Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

STUDIES OF THE OCEAN¹

By H. S. H. THE PRINCE OF MONACO

AFTER exploring for five and twenty years all the levels of the North Atlantic Ocean, from the tropical to the polar regions, chiefly in order to enlarge our knowledge of zoological and physical oceanography, I was commencing more especially such studies as concern physiology, when the German war came and upset the lives of all workers. Eight years were then wasted in the activities of those men who devote themselves primarily to the chief interests of humanity.

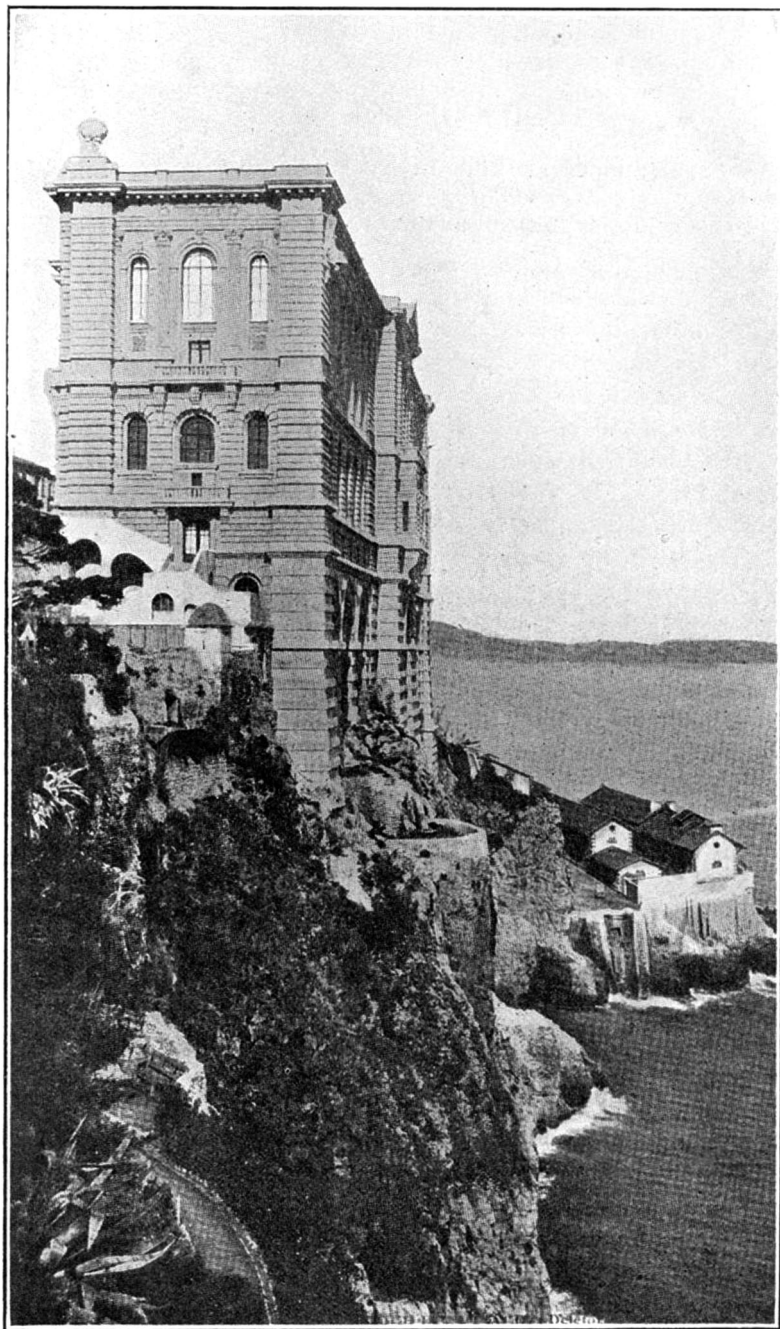
Yet such is to-day the power of human thought that in the whole course of the war my oceanographical laboratories never desisted completely from this appointed task; and I was gratified with the sight of two hundred thousand boys of your army visiting the Museum at Monaco while staying on our sunny shore either to heal their wounds or to improve their strength.

When I gave more prominence in my scientific undertakings to physiology, I enjoyed the cooperation of such noted scientists as Charles Richet and Portier, or a few younger men who were thus preparing for their future. Joubin and Bouvier had previously visited with me the awful spaces of the ocean, which almost daily yielded tons of beings unknown to science—abyssal cephalopods or pelagic crustacea. Buchanan and Thoulet, those veterans of the early great labors dealing with the sea, have been for thirty years closely connected with my investigations. And the head of that pleiad, the like of which is hardly likely to be seen again in the laboratory of any ship, was Richard, director of the Oceanographical Museum at Monaco, the faithful fellow-laborer in all my voyages and consequently of all oceanographers, the best versed in our science as a whole.

Owing to Dr. Richard's ingenious ideas and to those of Commandant Bourée, there have been of late years made available large nets with extremely small meshes with which I have explored the intermediate depths of the ocean from the surface down to over 5000 meters. In some instances it has been possible, by means of a special bathometer attached to the net, to ascertain at about what level the capture has taken place.

It was already known that there exists between the great depths and the surface of the seas a fauna consisting of many species and wearing a unique aspect. A sample of that singular world is sometimes

¹ Address before The National Academy of Sciences, April 25, 1921.



THE MONACO OCEANOGRAPHICAL MUSEUM FROM THE GARDENS OF SAINT MARTIN

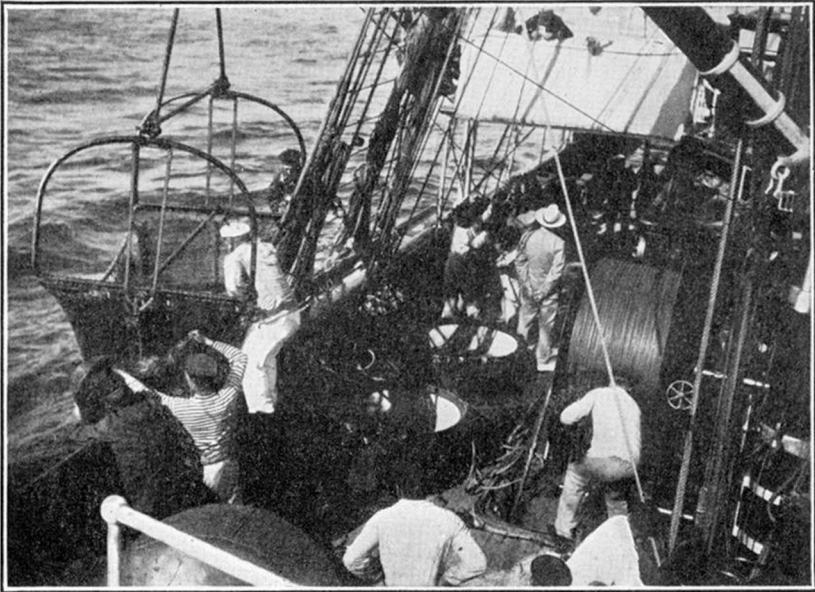
found floating as a corpse in the very early morning before the sea-birds have picked up these remnants of nightly struggles for life. After the improvements in our operations, unexpected facts were gradually brought to light and confirmed by other oceanographers. And in 1912 I obtained, by turning to account the bathometer above mentioned, which had been manufactured in Germany with great difficulty, the true curve of the levels the net had passed through in one operation.

Shortly after, I was able to make a net the opening and closing of which could be controlled on board the ship. This ensemble of improvements enabled us to establish, by means of operations carried out by day and by night at various depths, that there exists in those vast spaces a whole bathypelagic world undergoing vertical oscillation by which some individuals are dragged up from the lowest level at which they live to within fifty meters of the surface, the process occurring only at night. Consequently, we now find at about midnight, quite close to the surface, strange animals which we formerly, when operating in broad daylight, had to seek through most elaborate means at a depth of several thousand meters. Hence we know that those animals live in a state of perpetual vertical oscillation the period of which is twenty-four hours. We have also found that such animals as are able to undergo this enormous displacement more frequently belong to the species provided with luminous organs.

Of the broad researches to which I have applied myself for over a quarter of a century in order to throw light on the problems concerning the science of the sea, I will mention here my investigation of the currents in the North Atlantic Ocean. Those motions of the sea waters, so varied and at times so extensive, which are chiefly brought about by meteorological influences, in their turn exercise a considerable influence over life in the seas. This occurs through the distribution of the plankton, which is an entire fauna of forms extremely minute and therefore unable to direct themselves among the sea-forces.

The plankton—the miniature animal and plant forms of the sea world—is, consequently, swept about by currents over special regions of the sea and is followed by troops of stronger animals that feed upon it and are themselves fed upon by a yet mightier fauna. So it comes about that there has been established in the living sea-world, from the plankton masses to the biggest cetaceans, a broad cycle wherein we see life constantly arising out of death, amid the waters striving for their equilibrium. Currents thus exercise supreme influence over the shoals of sardine or herring, as well as a good many other fish which they supply with food under such conditions, that once upon examining the stomach of one of those fish, we could calculate the number of peridinians lying there at twenty million.

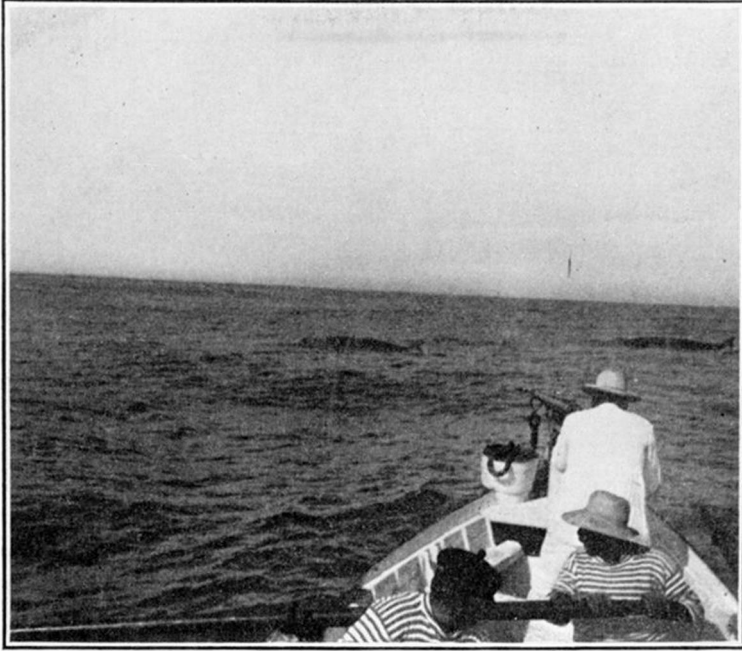
Out of the ensemble of the facts concerning the history of sea-



DREDGING WITH THE NET ON BOARD THE "PRINCESSE ALICE," THE YACHT BUILT BY THE PRINCE OF MONACO FOR THE STUDY OF OCEANIC LIFE. VOYAGE OF 1908

organisms I see more convincing grounds arise for regarding the sea as the cradle of life. Looming on the horizon of human knowledge, I descry the line of the species sprung one from another as they are distributed between surface and bottom. And while I compare that world, which has remained homogeneous through the ages, with those more distinct animals held on one plane on the earth's surface as though they had fled from the ocean it seems to me that the whole of this terrestrial fauna because of its slower evolution tends to speedier disappearance, owing to the unstable light environment. A few groups, the pinnipedes and cetaceous mammals, for instance, have not been able to gain even the requisite fitness and have remained half and half, with imperfect means of breathing and locomotion.

Having for a score of years observed the currents of the North Atlantic Ocean by means of extensive experiments based on organized flotation methods, I was, when the German war broke out, quite prepared for the question of what becomes of the wandering mines drifting from the mine fields which were soon placed near the coasts of both continents. I again took up my previous formulæ which had enabled me to draw a chart of the great currents sweeping along or connecting Europe and America, and owing to the similarity between the drifting of mines and the method I had used during my earlier investigations it became possible for me recently to present the navigators on the North Atlantic Ocean with a very accurate chart of the course followed by those formidable engines. On this chart one can see an



AIMING AT A WHALE (1902)

immense cycle, whose center is indicated by the Azores, described by the mines in a period of about four years, such being the space of time necessary for the completion of their voyage from the English Channel to the Canaries, the West Indies and back.

My calculations for this work are accurate with respect to the direction and the velocity of the currents, for the hydrographical and meteorological officers on both sides of the ocean observe the passing by or meeting of mines in the manner I had announced to navigators. The two sets of results mutually confirm each other after thirty-five years' interval.

I will content myself with quoting here some phenomena connected with orientation in animals in their relation to the sea.

One of my operations, carried out with a large fish-pot at a depth of about 1500 meters, brought up not only very large *Geryon* crabs, which had been caught inside, but a number of the same clinging to the outside. Thus I witnessed the perplexity the latter must have been in through want of resolution when the fish-pot was just leaving the bottom. They were merely crawlers, unable to swim; and a sudden separation from the bottom whereon the apparatus was lying prevented them from being resolute enough to drop back to their environment by simply falling down the very small height by which at first they were separated from it. They allowed themselves—for they were found to be thoroughly alive—to be lifted through a height of 1500



FIRING A LANCE HARPOON FROM A CANNON AT A WHALE IN THE ARCTIC OCEAN.
Photograph by Lieutenant Bourée

meters up to the surface in spite of the inconvenience they must have felt owing to the change in temperature and the decrease in pressure.

Another time, in the Mediterranean between Corsica and France, I met with a large whale which was apparently repairing to a pre-determined goal, and accompanied it with my ship the "Princesse-Alice," keeping close to its flank. For six hours it went on the same compass-route, without departing from it more than two or three degrees, covering about 40 kilometers without a deviation although there was no visible object to guide it. Moreover, its divings and surface breathings, as measured with a chronometer, showed no marked differences, 10 minutes under water alternating with 6 to 8 breathings.

Lastly, with respect to terrestrial birds flying over the sea in their migrations, I have always found facts showing complete lack of orientation under definite circumstances. Thus they swerve from their northward or southward route when there is no more land in either of these directions. The migratory birds swept by some storm away from continental Europe at length drop down to the sea, lacking the instinct which would help them to find the lands that sometimes lie a short distance eastward.

On the other hand those birds which in their chance-guided endeavors have been so lucky as to reach the Azores never afterwards left them. Several of these islands are therefore peopled with wood-



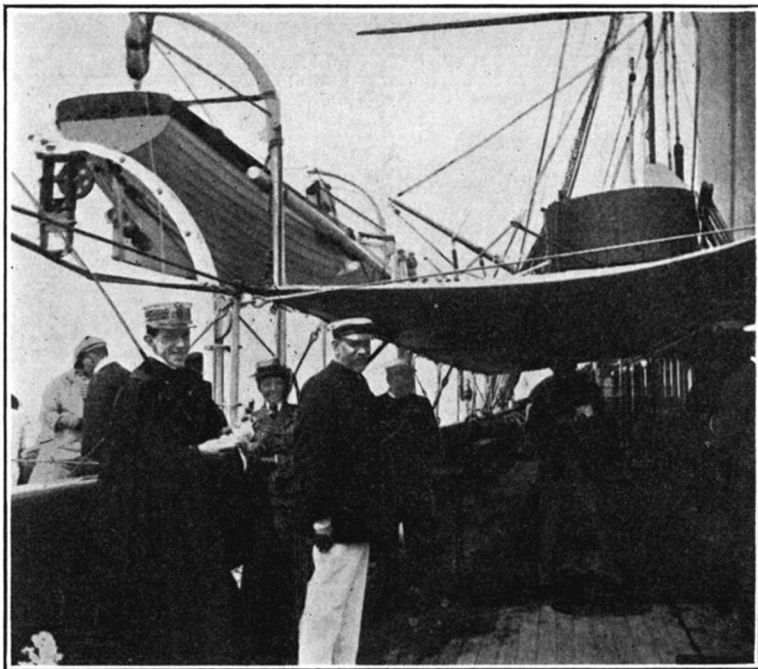
A METEOROLOGICAL KITE FROM THE EXPLORING YACHT IN THE MEDITERRANEAN
(1906)

cock and quail and wood-pigeons, which never depart; and there can be visited at São Miguel de Ponta Delgado a large collection of species captured under those circumstances.

With regard to phenomena relating to light, Messrs. Bertel and Grein have pursued very important investigations at the Monaco Oceanographical Museum concerning the penetration of the various light radiations into the depth of sea-water. Mr. Grein in particular has succeeded in securing a photographic print on highly sensitive plates exposed between 10 a. m., and 1 p. m., at a depth of 1500 meters.

The main results may be stated as follows: If we set down as 1000 the amount of light radiations reaching 1 meter down, we find that there remains at 5 meters but 3.7 of red and at 50 meters but 0.0021; at 5 meters there remains but 2.5 of orange-yellow and at 100 meters but 0.001. For green the figures are 230 at 5 meters and 0.0003 at 1000 meters; for blue they are 450 at 5 meters and 0.0001 at 1000 meters; for violet blue, 866 at 5 meters, 0.003 at 1000 meters, and 0.00001 at 1500 meters.

It was already known that the light radiations were absorbed in the above order but in what ratios they reach various depths was not known. M. Grein has moreover stated the ratios of the various percentages of radiations at any given depth: thus at a depth of 1 meter there are 96.7 per 1000 of red; 165.7 of orange yellow, green and



THE KING OF SPAIN (LEFT) AND THE PRINCE OF MONACO (RIGHT) ON BOARD THE PRINCE'S YACHT, THE "PRINCESSE ALICE," AT ST. SEBASTIAN. (JULY, 1903)

green blue; 198.9 of blue; and 207.3 of violet blue. Below 1000 meters only blue remains and below 1500 meters only violet blue.

But there is still one question of biology that offers a very great deal of interest. On my ship Dr. Charles Richet, assisted by Dr. Portier, brought to light the following facts: The tentacles of certain marine animals like *Physalia* provoke by simple contact local irritation and hypesthesia. When injected with the extracts from these tentacles the dog, the pigeon, and other animals are plunged into a state of conscious semi-narcosis more or less prolonged during which they remain absolutely insensible to pain. Richet and Portier have named this benumbing substance "hypnotoxine."

In experimenting with extracts from the tentacles of certain sea-anemones, Richet and Portier found that dogs after having received one injection became *excessively susceptible* to the action of a second dose. These dogs could be killed by a quantity representing only a fraction of the dose that would be fatal for a dog not previously treated. They gave the name "anaphylaxis" to this state of abnormal sensitiveness of a subject to the action of certain substances, which might be foreign albumens of any kind, animal or vegetable; for example, the blood-serum of an animal of a different species, egg-albumen, substances usually harmless like milk, the extracts of various organs, bacteria or the extracts from bacteria (bacterial proteins) etc.

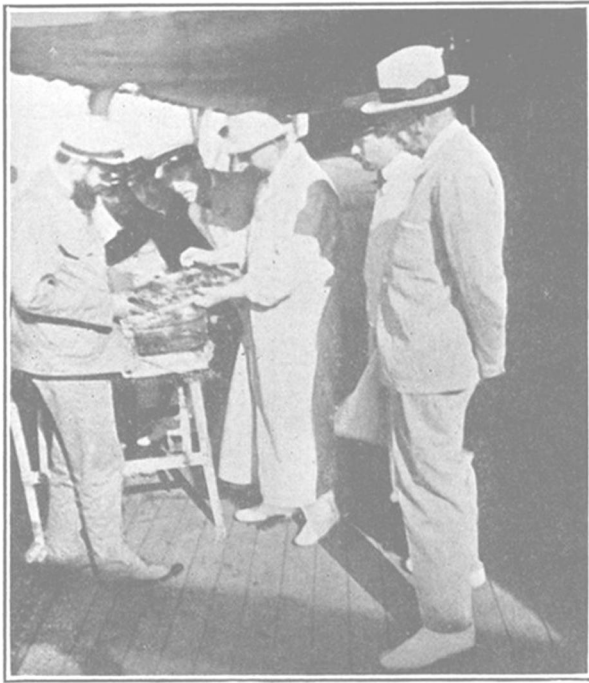


THE PRINCE OF MONACO (RIGHT) AND MR. KOHN (LEFT) ON BOARD THE "PRINCESSE ALICE" ON THE VOYAGE OF 1905. Photograph by Dr. Richard, Director of the Monaco Museum

If, for example, a small amount of serum from the horse, even one one-hundredth of a cubic centimeter, is injected into a guinea-pig, the latter is rendered hypersensitive to horse serum. This hypersensitivity goes *completely unnoticed* unless after a certain lapse of time the guinea-pig is again injected with serum from the horse; under these conditions the anaphylactic state reveals itself by a condition of "shock" with grave symptoms and sometimes even death in a few minutes.

There was at first considerable surprise and incredulity because scientists had hitherto been accustomed to regard the reaction of immunization or of diminution of sensitiveness as the appropriate response of an organism to the injection of foreign substances. It was therefore astonishing that exactly the opposite phenomenon could result. Thus the laws of immunity were completely upset.

Though but a few years have passed since the condition of anaphylaxis was studied for the first time, it has now become one of the subjects which have brought forth the most work in the domain of immunity. The amount of research carried out upon anaphylaxis is enormous, and every day its literature increases. It is a field of the highest importance not alone on account of its practical application in serum therapy but because as a mystery it enfolds within its depths the secret of many deep-seated questions relating to mankind; also



EXAMINING A CATCH OF THE BOUREE NET

because the researches already performed upon anaphylaxis give great hopes for the elucidation of these questions and for the discovery of a method of rendering the human body insusceptible.

Among the things which contribute to the harmony of our terrestrial sphere we should observe the rôle played by the marine plants as frequently intermediaries between the living and the lifeless realms of our planet. While on the one hand they furnish for many organisms both protection and nourishment, still another important function falls to their lot: they fix certain mineral substances which are more or less abundant in the bosom of the ocean and deliver them up for exploitation by human activity. Thus it would be eminently fitting to conserve and to cultivate these products of the sea which are to-day our auxiliaries in obtaining iodine, bromine, algine, chloride of sodium, and the salts of potassium, magnesium, lime, iron and manganese. Unfortunately in some places they are already the victims of waste. Finding himself in the presence of wealth, one might say, man loses completely the idea of providence. He seems then to suffer from a vertigo which drags him to the radical destruction of things for there is no gift of nature that can survive the ill-considered enterprises of human industry.

Paul Gloess has said: "It is in the marine plants that we find, and shall always find with more certainty than elsewhere, that which thus far in our carelessness we have neglected to ask of them or which



A FISHING SCENE ON BOARD THE "HIRONDELLE," THE YACHT BUILT BY THE PRINCE OF MONACO FOR OCEANIC EXPLORATION. FROM LEFT TO RIGHT ARE PRINCE ALBERT I OF MONACO; L. TINAYRE, ARTIST; DR. RICHARD, DIRECTOR OF THE MONACO MUSEUM; M. FUHRMEISTER, PRIVATE SECRETARY, AND DR. LOUET, PHYSICIAN

in our extravagance we have squandered. * * * The fertile soil of the earth is constantly becoming poorer while the nourishing fluid of the sea is growing richer and richer."

All these data are valuable for the study of the beings living at various depth-levels in the ocean.

A professor at my Oceanographical Institute, Monsieur Joubin, has lately suggested the use of seaplanes to help open-sea fishermen by guiding them towards the shoals of the fish they are seeking while the latter in their turn are pursuing large shoals of such crustacea as serve them for food. For instance, it has been found that the germon (the blue tunny in the Bay of Biscay) is plentiful in the places tenanted by certain red-colored amphipodous crustacea (*Euthemisto*) of which the germon is fond. Seaplanes would have no difficulty in signalling to fishermen those red fields which distinctly mark off certain spaces in the sea and move about as they are swept by the currents. Again, they could signal the presence of various other shoals recognizable by different signs. Thanks to this cooperation, fishermen might save time and much undue wear of their nets.

Now I shall take up a matter which I have had in hand for some time and which is one of a really serious nature. I mean fishing generally, the destructive effects of which are becoming greater and greater in the seas where more and more powerful and numerous implements such as steam trawlers are being used. The latter now graze

the very soil of continental plateaux, plucking off the sea-weeds and ruining the bottoms that are fittest for the breeding as well as the preservation of a great many species. So much so that in a few years' time the means of maintenance of hundreds of thousands of fishermen and their families on the coasts of Europe will have disappeared.

The trawlers steadily work farther and farther, deeper and deeper, in ever increasing numbers; and wherever their devastation is possible a waste is involved which certainly exceeds 50 per cent. of the edible produce they seek. For we must include in this summary valuation the young the trawl maims and kills as it passes and those that reach the ship in such condition that they are useless and in some cases untransportable. Near the Arguin bank on the west African coast a still more intensive waste occurs which is owing to purely commercial causes.

In order to check this evil, I suggest the meeting of international conferences possessing the most drastic powers to enforce the decisions that are to be arrived at. I would recommend the adoption of the reserved district principle, which has always been very efficient for the preservation of wild terrestrial species, because it rests on logic and simplicity. Besides, it is now showing its value in those parts of the sea where the war raged and fishing was held up for a few years; as soon as fishing was resumed plenty of fish has been found, some specimens being of a size unheard of for thirty years.

I have included within the domain of oceanography, for the present at least, the study of phenomena observed in the upper atmosphere floating over the oceans. That these expanses receive from the sea the principal elements of their activity seems evident when one remembers the effects of evaporation on an immense scale and of the winds which sweep continually over the surface of the waters.

Only with a great deal of difficulty have we succeeded in obtaining observations on the speed and direction of the wind and the temperature and humidity of the air up to altitudes of 25,000 meters. During several years I pursued, by means of aluminum instruments weighing very little, the delicate experiments which these researches entail. In the construction of these instruments Professor Hergesell, who now accompanied me, had participated. Just as the Americans, Edy and Rotch, had already done, I at first entrusted my instruments to kites which carried them up to 4500 meters. But soon I abandoned this means and adopted a new one which, on land, furnished satisfactory results to the French investigators Hermite and Bezancon. This was an arrangement of two linked balloons unequally filled, of which the one less inflated carried the instruments. On reaching a certain height the better filled balloon would be burst by the expansion of the gas it contained, whereas the second, not sufficient alone to carry the weight of the instruments, redescended toward the surface of the sea. I was able to make such apparatus reach an altitude of 14,000 meters.

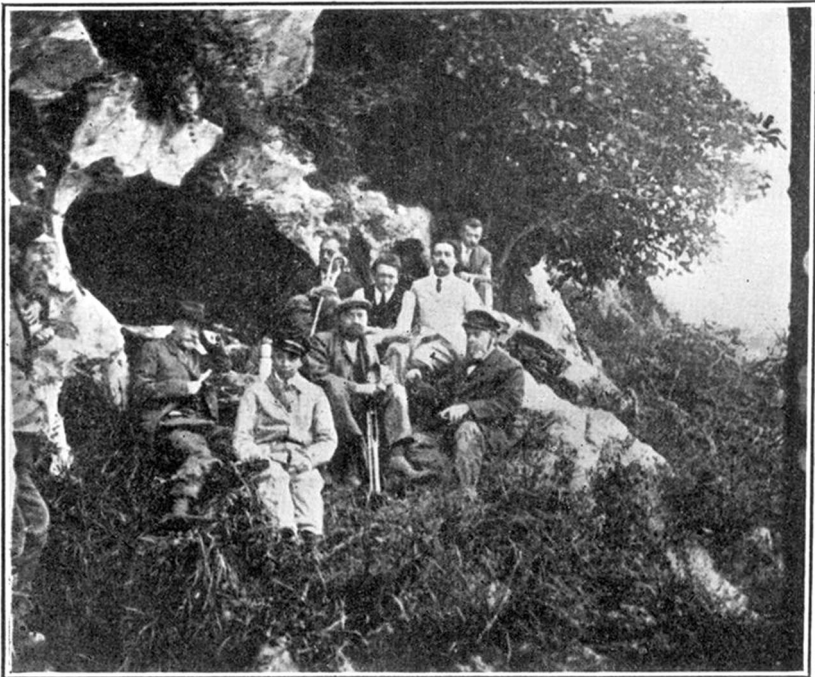


THE PRINCE OF MONACO VISITING THE GROTTA DEL CASTILLO, SPAIN, WHICH HE EXPLORED FOR PREHISTORIC HUMAN REMAINS. THE PRINCE IS SEATED ON THE RIGHT OF THE CAVE'S MOUTH, WHILE ON THE EXTREME LEFT STANDS HIS COLLABORATOR THE ABBE BREUIL, AND NEXT TO HIM THE ARTIST OF THE EXPEDITION, LOUIS TINAYRE.

The most serious difficulty presented in these operations was always that of recovering the balloon that carried the instruments after its descent to the sea, since the point of its fall was sometimes 50 to 100 miles distant from that of its ascent and in a direction quite different from what the wind at lower levels would indicate. Moreover, the whole apparatus, though followed by the ship and located repeatedly as long as it remained visible, would finally disappear without our being able subsequently to judge the effect of the wind which carried it.

On board the "Princesse-Alice II" we solved this problem by special calculations which allowed us to mark on a map, as soon as the balloon had disappeared from view, an approximate point toward which to direct the course in order to rediscover it without fail. Thanks to an ingenious idea of Professor Hergesell, this balloon left to itself remains floating with its instruments at a height of 50 meters above the water, its lifting power being recovered through a weight suspended below which has only to touch the surface.

By using much smaller balloons, of about 1-meter size, which carried no instruments but the movements of which were measured with the theodolite as long as it was possible to observe them, we succeeded, in arctic regions, in determining the velocity and direction of the wind in the upper layers of the atmosphere, even up to 25,000 meters, as before mentioned. Then our balloon was 80 kilometers from us in a straight line; that such a visibility is possible results from the limpid



THE PRINCE OF MONACO AND HIS PARTY VISIT THE GROTTA OF LA PASIEGO, NEAR PUENTE VIESGO, NOT FAR FROM SANTANDER

arctic atmosphere free from dust and water-vapor. This same limpidity permitted me one day to follow easily all the actions of 4 men whom I had sent on a mission to a snowfield situated at a distance of 40 kilometers towards the interior of Spitzbergen.

To-day, therefore, I can release in the open ocean a balloon of 2- or 3-meter size furnished with instruments and can find it mathematically after it has made a long journey in a direction of which we otherwise would have to remain totally ignorant.

I shall close my all too brief survey of the mighty domain created by the science of oceanography by speaking to this distinguished assembly of the bathymetric chart of all the seas of the globe the preparation of which I undertook at the time of the International Congress at Berlin in 1899. I realized then that this task was necessary as a basis and a program for the great work to which I have consecrated my life. To Commandant Bourée I entrusted the direction of this enterprise and to-day its imperativeness is already evident. All the hydrographic and oceanographic centers of the world have appreciated this fact and are now sending me abundant data bearing on the subject.

This chart, on a scale 1 to 1,000,000, occupies 24 sheets and measures, without its separate polar circles, 2 meters 40 cm. by 4 meters. The isobathic lines are those of 200, 500, 1000, 2000 meters, and so on.

The surfaces contained between succeeding contours are colored in blues becoming progressively deeper in shade. The oceanic regions of which the depth still remains unknown are immediately disclosed.

If we had no more rapid system for taking soundings than that which requires each time the stopping of the ship to send a lead to the bottom, many years would still be required for the completion of such a task; but the method of M. Marti, a hydrographic engineer in the French navy, will doubtless soon enable us to take lines of soundings with almost the usual speed of a ship under way.

M. Marti obtains the marking upon a very sensitive recorder of a slight explosion produced always under the same conditions. This record being repeated in like manner by the echo sent back from the submarine floor allows of a measurement of depth with greater precision than by any other procedure. The principal experiments have been carried on at the Oceanographic Museum of Monaco and it is to be hoped that M. Marti's method of sounding will be employed everywhere. When applied to slight depths it would render great services to navigation; and as for my bathymetric map, it would very soon be completed.

I have already told you that my life has been occupied in anthropological research as well as in oceanographic studies. My conjectures on the origin of life in the sea carried with them as a necessary corollary the formation of a group of beings susceptible to the laws of evolution in such a way as to be led toward the synthetic whole that has become the human form. Hence it was necessary to seek in the series of marine animals, either among the living or among the fossils which led the same life, whatever indications might shed light upon such a question. From what marine ancestors has come the stem of anthropoids from which one may ask the secret of the drama in which we are now taking part?

In the midst of these reveries came the desire to found, under the conditions of independence necessary for the development of scientific truth, a home where anthropology could grow freely in the solicitude accorded by the most trusted disciples of this science. So I created beside the Oceanographic Institute of Paris the Institute of Human Paleontology, where the professors without gathering cumbersome collections study all the materials with which excavations supply us.

I come among you the better to express my happiness and my pride in the great favor you have done me by bestowing upon me this medal which commemorates the work of oceanographers. Nothing could honor more the efforts to which I have consecrated my life than the spirit of men might no longer be left ignorant of all that concerns the science of the sea when it had already penetrated so many secrets of the earth, this infinitesimal portion of the universe.